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## *Energy Modeling*

# Beyond National Economy-wide Rebound Effects

By Simon Koesler, Kim Swales, and Karen Turner\*

### Introduction

The potential for rebound effects in energy consumption to erode anticipated energy savings from increases in energy efficiency are the subject of much academic debate and increasing policy concern. Rebound occurs where the potential energy savings from efficiency-enhancing innovations are partially (or perhaps even wholly) offset by a variety of economic responses. For example, cost-effective energy efficiency improvements in industrial energy use lowers the marginal cost of energy services, thus encouraging increased use of those services, as well as lowering output prices, boosting economic productivity and competitiveness (both in the sector where efficiency improves and down-stream) and thereby triggering a general economic expansion in the region/country where the efficiency improvement takes place. The energy use associated with this expansion gives what is referred to as the economy-wide rebound effect. However, expansion may be limited, with crowding out in some sectors where supply constraints exist, and with potential contraction in energy supply activity where there is a net decrease in energy demand as a result of the efficiency improvement. Therefore, economy-wide rebound may be expected to consist of a mix of positive and negative pressures on energy use across the economy in question (see the corresponding author's recent review in *The Energy Journal* 1).

Here we argue that the common national focus of energy rebound should be extended to an international context. Specifically, given the global nature of today's goods and factor markets generally, and energy supply in particular, national actions to reduce domestic energy use through efficiency improvements may impact energy use in other regions. This is an important issue particularly in the context of multiregional policy frameworks such as the European Union's 20-20-20 package, as it implies that national targets and actions cannot be considered independently.<sup>2</sup>

### Energy Efficiency Spillover Channels

We identify three broad channels through which rebound effects from increased efficiency in industrial energy use (the nature of international spillover effects and rebound pressures may differ to some extent where efficiency increases in residential energy use) may spread from one country to its trade partners.

First, consider general demand channels. When technical efficiency increases in productive energy use this equates to a positive supply-side shock in the nation where the improvement takes place, leading to falling prices and increased competitiveness. The most basic impact will be a general expansion in activity on both the production and final consumption sides of the domestic economy. Where producers and final consumers use a combination of domestic and imported goods and services, positive income and multiplier effects will stimulate both foreign and domestic production, allowing the benefits of the expansion to spread to the wider global economy. This would underlie concerns that rebound in energy use will grow as the boundaries under consideration expand. However, where there are any constraints in factor supply conditions in different regions, there will be opposing upward pressure on prices, which will in turn put downward pressure on economy-wide rebound, although increased factor returns will generate positive income effects. Thus, this channel generates a mix of positive and negative pressures on rebound in global energy use.

Second, we identify a related competitiveness channel. An increase in the energy input efficiency in a target sector/country causes a shift in comparative advantage of this sector relative to its counterparts in other regions. Moreover, the benefits enjoyed by the targeted sector will spread to other (domestic and external) sectors that use the targeted sector's outputs as intermediate inputs. However, the nature and strength of international spillover effects will depend on contraction in external sectors whose competitiveness is reduced relative to the targeted sector, and any negative impacts on related supply chains and factor returns.

Third, we consider energy market channels. Changing demands for the outputs of energy supply sectors may result in three types of effects. First, any reduction in energy demand will ultimately reduce the overall amount of produced energy. Because energy supplying sectors are generally relatively energy intensive, this by itself will curb energy use in the energy supply chain, both at home and abroad. The extent to which this will decrease local and/or foreign rebound depends crucially of the location of the main energy supply of sector and wider economy

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See footnotes at end of text.

where the efficiency improvement takes place. However, the initial decrease in energy demand as efficiency improves will generate downward pressure on domestic and – if energy markets are sufficiently integrated – also external energy prices. Where energy prices are depressed due to excess capacity, this will trigger additional energy demand and put upward pressure on rebound in the respective regions. On the other hand, if revenues and returns to capital fall, over time the incentive to maintain/invest in energy supply capacity will be negatively affected. As energy supply conditions tighten, market prices for energy are likely to rise, thereby offsetting positive demand pressure driving rebound.

### Preliminary Results for the Case Study of Increased Efficiency in German Industrial Energy Use

Quantitatively, the influence of each of these channels on overall ‘global economy-wide rebound’ effect will vary depending on the structure of existing trade linkages between regions that have and have not directly benefited from increased energy efficiency. We close with some results from an initial case study for Germany, where we use a static multi-sector, multi-region interregional computable general equilibrium modelling (CGE) framework to simulate a costless and permanent 10% improvement in energy efficiency that is first applied to all German production sectors and then limited to the composite manufacturing sector. In the results reported below we assume that total supplies of labour and capital are fixed at the national level. We identify four levels of rebound effect that incorporate all economy-wide impacts (as determined in a general equilibrium context) but with attention focused on: (1) the targeted sector; (2) on all industrial/productive energy use – where (1) and (2) coincide where all production sectors are targeted with the efficiency improvement – (3) on all domestic (industrial and final consumption) in the home economy; and (4) energy use in the global economy, first considering energy use within the EU before total world energy use.

Table 1. General equilibrium rebound effects from a 10% increase in industrial energy efficiency

	Own sector	Own-country production	Own-country total	Global	
				EU	World
(a) Increased efficiency in all German production					
Rebound (%)		46.60	50.18	47.28	46.58
Percentage point change			3.58	-2.90	-0.70
(b) Increased efficiency in German manufacturing					
Rebound (%)	56.44	47.63	51.31	50.22	48.11
Percentage point change		-8.81	3.68	-1.09	-2.11

Table 1 reflects our findings (reported in detail in the full conference paper) that in the case of a general efficiency improvement across all German production sectors, positive effects on external production and energy use via the general demand channels are offset due to a relative reduction in foreign competitiveness. On the other

hand, where only German manufacturing is targeted with the efficiency improvement, non-competing external sectors are positively affected. However, negative impacts on external manufacturing through the competitiveness channel are sufficiently strong to be the main determinant of the observed contraction in economy-wide rebound in moving first from German to EU-wide then the global level. Moreover, with fixed factor supply, other German production is also crowded out, causing the contraction (8.8 percentage points) in own-country economy-wide rebound as we move from the sectoral to total production level.

In terms of the third spillover channel identified, the energy market channel, contractions in both domestic and external energy supply chain activity resulting from the initial demand reduction as efficiency improves dominate the results in Table 1. These are found to have the strongest negating impact on rebound (at all spatial levels), and this is more so the larger the efficiency improvement (i.e. where the efficiency improvement is applied to all German sectors). When we limit the efficiency improvement to German manufacturing, which has a relatively low energy-intensity to begin with, positive demand effects in energy supply from boosted activity in household consumption in all regions, and in other European and Non-European production sectors, lessens the negating impact of the energy market channel on rebound at all levels.

### Conclusions

This preliminary study suggests that increases in energy efficiency in one nation are likely to impact energy use in others through several channels. The key finding reported here is that changes in relative competitiveness and energy supply conditions will potentially act to dampen economy-wide rebound as the boundaries of the economy are expanded. However, the sectoral and spatial distribution of positive and negative effects will depend on the nature of the efficiency improvement and factor supply conditions, both of which merit further investigation.

### Footnotes

<sup>1</sup> Turner, K. (2013) Rebound effects from increased energy efficiency: A time to pause and reflect, *The Energy Journal*, 34(4), 25-42.

<sup>2</sup> For more information on the European Union’s 20-20-20 package please see: [http://ec.europa.eu/clima/policies/package/index\\_en.htm](http://ec.europa.eu/clima/policies/package/index_en.htm)